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ABSTRACT

The main objective of this program was to produce animated educational material to stimulate students' interest and learning process related to the sciences and to measure their impact. The program material was designed to support middle school educators with an effective, accessible, and novel didactic tool produced specifically to enhance and encourage the learning of chemistry. The study introduced the Periodic Table of the Elements, utilizing materials developed for middle school students in two distinct formats: printed material in English or Spanish, and an animated video with English or Spanish language narration. Participants were 320 students in middle schools in Mexico and Texas. A questionnaire was administered to assess learning. The results compare the difference between the students' ability to recall and comprehend complex subjects as presented by linear multimedia as opposed to printed text. The study additionally offered an opportunity to observe the advantage of applying a narrative format to procedural text. It is concluded that, in both countries, students appeared to be more attentive to the animated material. (AEF)

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Linear Multimedia Benefits to Enhance Students' Ability to Comprehend Complex Subjects

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Abstract: Living in the information age has increased the complexity of our forms of communication, especially in education. Computer-controlled combinations of text, graphics, sound, photographs, film, and other types of media have surrounded our lives, thereby transforming the traditional educational process. In spite of the allurement of these sophisticated, modern communication systems; laserdiscs, videofiles, CD-ROMs, etc., these materials enhance, rather than replace, the traditional teaching style. Nonetheless, educators are challenged with creating innovative contexts for learning that expand the students' ability to recall and comprehend complex subjects in a competitive, media-communication environment. There are two, major categories of multimedia: non-linear or interactive and linear. Both utilize similar elements: text, graphics, animation, sound, and video. Video production is considered linear multimedia. This research measures the students' ability to recall and comprehend complex subjects utilizing linear multimedia and its benefits.

Introduction

Designing an ideal environment to teach and learn sciences requires a considerable effort of educators. The subject's inherent complexity challenges the educator's ability to explain and interest the students at the same time. In spite of the technology's advancement, teaching science is still complex even if the digital and multimedia resources have redefined literacy and learning (Negroponte, 1995).

The information age has increased the complexity of our forms of communication, especially in education (Casey, 1997). Computer-controlled combinations of text, graphics, sound, photographs, film, and other types of media have surrounded our lives, thereby transforming the traditional educational process. In spite of the allurement of these sophisticated modern communication systems; laserdiscs, videofiles and CD-ROMs as well as other supporting technologies, these materials enhance, rather than replace, the traditional teaching style. The technologies that surround us need to effectively support the teacher's central role in orchestrating the learning experience instead of replace it. The new digital communication tools present a potentially richer opportunity to use images in movement instead of traditional print media to explain complex subjects. In addition to learning and understanding sciences, other forms of communication can be utilized to promote an interest to learn, including animation.

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Character animation is the basis of most children's primary choice of entertainment. Television, feature films, video arcade games, and home video games are probably the most popular media venues in the market. Despite their respective popularity, animation production is a time-consuming task, requiring skilled professionals and specialized equipment. Because of this fact, most available educational productions are developed in what is known as non-linear or interactive multimedia. CD-ROMS and WEB browsers are included in this multimedia category. Users of this technological development control the content and go to any part of the application at any time. This feature confers independence to the user, which may result in an unstructured learning environment.

Linear multimedia, such as video production, utilize the same elements as non-linear multimedia applications; text, graphics, animation, sound and video. Linear multimedia presents information in a logical, systematic sequence, allowing the educator specialized or standardized support for group exposure to complex elements at any particular time.

This paper describes the first phase and results of a program whose main objective is to produce animated educational material to stimulate the students' interest and learning process of the sciences and measure their impact. The program material is designed to support middle school educators with an effective, accessible and novel, didactic tool produced specially to enhance and encourage the learning of Chemistry.

This study introduced the Periodic Table of the Elements, specifically developed for middle school students in two distinct formats: A printed narration, and an animated video with an English or Spanish language narration. The results compare the difference between the students' ability to recall and comprehend complex subjects as presented by linear multimedia as opposed to printed text. The study additionally offered an opportunity to observe the advantage of applying a narrative format to procedural text. The study was performed in the border region between USA and Mexico in the cities of El Paso, Texas and Ciudad Juarez, Chihuahua, Mexico.

Methodology

Materials

An animated videotape and printed material were the primary instruments of the study. Both utilized a format that combines narrative and descriptive text. *Narrative text* includes a recital of facts and *descriptive text* a series of sentences describing objects or persons and a series of events that cause a change in state (processes) around a common theme (Large et al. 1995). According to some studies, animation has been found to enhance procedural texts (a series of actions executed by someone or something to achieve an explicit goal) but not descriptive texts (Large et al. 1994). The narrative of the videotape has the basic structure of a drama, including characters, setting, conflict, and resolution. The protagonist, a child in a wheelchair, was a medium for the audience to empathize with the difficulties in understanding and learning. The videotape is organized in blocks. At the end of each block, the essential concepts are summarized and reemphasized. The videotape introduces the structure of the elements, Dmitri Mendeleyev's first organization of the periodic table of the elements, the current organization, and gradually explains more complex subjects. The more detailed information includes; the elements' physical and chemical properties, the arrangement of electrons in the orbits or energy shells, valence, reactivity, and the differences between the groups or families.

Videotape

A ten minute, fully animated videotape with an English or Spanish language narration, featuring a child in a wheelchair researching the Periodic Table of the Elements. The English version of the videotape was shown only in the United States schools and only the Spanish version was shown in Mexico.

Written Material

The narration from the videotape was used as a basis for the printed material. The only difference between the videotape narration and the printed text was the omission of references to the protagonist. These exclusions were irrelevant to the primary concepts and would be confusing without a visual reference. For

example, the animation depicts a scene where the main character becomes dizzy from attempting to memorize all of the chemical elements.

A Spanish language equivalent of the written text was produced from the Spanish version of the videotape, as opposed to translating the English printed text. The text consists of approximately 815 words without any images.

Questionnaires

Ten, multiple choice questions were included in both the Spanish and English language questionnaires. The questionnaire progressed from simple questions to more advanced. A clear understanding of the material was required, as the various choices were very similar, yet only one was the correct response.

The following is an example:

Lithium has three electrons. This means:
1. The first orbit has one electron and two electrons in the 2^{nd} orbit
2. The first orbit has two electrons and only one electron in the 2^{nd} orbit
3. The first and second orbits have one electron each and one in the third orbit
4. Do not know

Groups

Students from 8^{th} grade in the US group and from 6^{th} and 7^{th} grades in the Mexican group participated in the study. The same grade level was not included in both countries, because the Mexican curriculum begins the study of Chemistry in the middle of the 7^{th} grade. The students required no prior knowledge of the study of the Periodic Table of the Elements to participate in the study. For that reason, the students were drawn from the 6^{th} and 7^{th} grades in Ciudad Juarez, Chih. and from the 8^{th} grade in the El Paso Area. The schools have different curriculums and facilities, despite the huge difference between the two countries economies, the students belong to similar socio-economic environments with respect to the rest of their respective area population.

A total of 320 students participated in the study, with the majority belonging to the Mexican group. This was due to the difficulty in finding similar socio-economic environments between the public schools in Mexico and the US.

School	Country	Group	Grade	N
A	US	Written Material	8^{th}	23
A	US	Videotape	8^{th}	27
B	Mexico	Written Material	7^{th}	74
B	Mexico	Videotape	7^{th}	83
C	Mexico	Written Material	6^{th}	59
C	Mexico	Videotape	6^{th}	53

Table 1: Group distribution by country and grade level.

Procedure

The students were explained the purpose of the study and randomly assigned to six groups with roughly equal numbers of boys and girls. Two groups from each grade level were assigned 10 minutes to either watch the videotape or to read the written material. Once they finished reviewing the material, the reading group returned the printed material and both groups received the questionnaire. Both groups were allocated 10 minutes to complete the questionnaire and return them.

Results

United States

Participants who viewed the videotape scored significantly higher on the questionnaire *(t = 4.0; df = 48; p< 001)* than those who read the printed version of the material.

8th grade	Mean	Median	Mode	N	Std. Deviation
Printed	7.30	7.0	8.0	23	1.61
Video	8.89	9.0	10.0	27	1.19

Table 2: Descriptive of 8th grade students in the United States.

Mexico

No significant difference was found between the responses of the groups that read the material and those who viewed the videotape *(t = 1.473; df = 268; p = 0.142)* .

6th and 7th grades	Mean	Median	Mode	N	Std. Deviation
Printed	5.83	6.0	7.0	134	2.21
Video	6.20	6.0	6.0	136	1.92

Table 3: Descriptive of 6th and 7th grade students in Mexico.

Participants from the 6th grade *(t = .470; df = 110; p = 0.640)* and 7th *grade (t = 1.302; df = 156; p = 0.195)*, who viewed the videotape did not scored significantly higher on the questionnaire than those who read the printed version of the material.

6th grade	Mean	Median	Mode	N	Std. Deviation
Printed	5.15	5.0	4.0	59	2.04
Video	5.34	5.0	5.0	53	1.69

Table 4: Descriptive of 6th grade students in Mexico.

7th grade	Mean	Median	Mode	N	Std. Deviation
Printed	6.36	7.0	7.0	75	2.04
Video	6.75	7.0	7.0	83	1.69

Table 5: Descriptive of 7th grade students in Mexico.

Discussion

The majority of students who watched the animation in the United States (37%) answered all multiple-choice questions correctly, as opposed to 8.7% of those who only read the printed material. Despite the reading group's lower percentage of perfect scores, the overall results were high, considering the complexity of the subject matter. These results suggest that the use of a narrative format in printed material can potentially improve understanding and the learning process (Rothkopf, 1966).

The 6th and 7th grade students in Mexico showed no difference in age or gender between those watched the videotape and those who read the printed material. The scores indicate a significant difference between the two grade levels *(t = 5.441; df = 268; p = 0.001)* that confirm the material would be more appropriately implemented in the 7th or 8th grade levels.

The students in Mexico had a wider distribution of responses, ranging from no correct answers to perfect scores. Whereas none of the participating students in the United States scored less than 50% correct answers.

Conclusions

The main purpose of the program's first phase was to determine the effectiveness of animated video material to enhance a descriptive text and improve the students' ability to comprehend complex subjects. The main objective of the second phase will be to contrast and compare the benefits between animated and printed material when used as didactic tools supporting educators in the instruction of complex subjects.

There is a significant difference between the Mexican groups who scored less than five correct responses after viewing the animated videotape as opposed to those who read the printed material. The correct responses recorded from their questionnaires corresponded to the most complex questions in the instrument, suggesting the presence of distractions during the testing. The large number of students and the small classrooms resulted in distractions while the participants answered the questionnaires. There is evidence to suggest the information process is affected in the presence of distractions. The public schools in Mexico do not have the facilities to minimize such distractions but the private schools frequently do.

Mexico's middle class has turned to the private sector for the education of their children. Many of the school's installations and equipment compare to the settings of the US public schools, suggesting the results of this study may differ in a more controlled environment.

In both countries, the students appeared to be more attentive to the animated material. Linear and non-linear animation has flourished in recent years warranting a place in the future of education. Other studies have indicated a significant advantage in applying animated material (Nicholls, et al. 1996). Further research will determine the optimum method for combining linear and non-linear animated material as a didactic tool, augmenting, instead of superseding the existing curriculum, while encouraging the students' interest to learn and study.

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